Space Weather Technical Forecast

Issued on Tuesday 17 December 2024 at 13:52 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: CME in progress, risk of further minor storms on Day 1, then easing.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Low solar activity, with a peak C4.5 flare registered at 17/0130UTC. There are five sunspot regions on the Earth-facing disc. AR3924 (Ehi/Beta-Gamma) remains the most complex sunspot group on the disc, but the region has shown stability. AR3922 (Dai/Beta) remains the most developmental on the disc but also remains stable. There is a large number of filaments on the visible disc, many of which have started erupting. The Earth is currently experiencing a CME thought to be from one of these filament eruptions early on the 15th. Further eruptions were observed off the East limb early on the 17th, unlikely to be Earth-directed.

Solar Wind / Geomagnetic Activity: Solar winds, as reported by ACE and DSCOVR at L1, showed a significant increase during the early hours of the 17th with the arrival of a CME at 17/0437UTC. Density rose sharply above average to around 47ppcc. The Interplanetary Magnetic Field (IMF), Bt, was initially weak but rose to 30nT by 17/0632UTC. The north-south component, Bz, oscillated between -10 and -21nT during the turbulent region of the CME between 17/0437-0630UTC before going strongly positive after 17/0730UTC (positively-orientated magnetic cloud). The phi angle was mainly positive (away from the Sun) and since the magnetic cloud settled, has become negative. This activity resulted in a G2 Moderate storm 0300-0600UTC, followed by a G1 Minor 0600-0900UTC, and is currently settling at Active (Kp4).

Energetic Particles / Solar Radiation: High energy proton flux observed by GOES18 was at background levels, though a minor enhancement in 10MeV levels was indicated between 16/2200-17/0200UTC. High energy electron flux (greater than 2MeV) observed by GOES16 was background. The associated 24-hour fluence was well below the Active (1e8 integrated flux) threshold. The 17/0000 UTC observation was 1.28e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Low to Moderate Solar activity is forecast with a chance of M-class flares, increasing slightly from Day 2 (18 Dec) onwards.

Solar Wind / Geomagnetic Activity: The CME currently being experienced at Earth is likely to wane after Day 1 (17 Dec), with isolated G1 Minor storms possible until it does, then, leading to a reduction back to Quiet to Unsettled (Kp1-3) conditions. Several other CMEs that left the Sun in the

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past few days are forecast as near misses, but cannot be completely ruled out as flanking arrivals at Earth, so there is some uncertainty in the forecast currently.

Energetic Particles / Solar Radiation: High energy proton flux is expected to remain at background, but carries a daily, slight chance (15%) of reaching S1/Minor Storm levels or greater, in response to any notable solar flares. High energy electron flux is expected to be at background to moderate levels. The 24-hour fluence is expected to remain below the Active threshold throughout.

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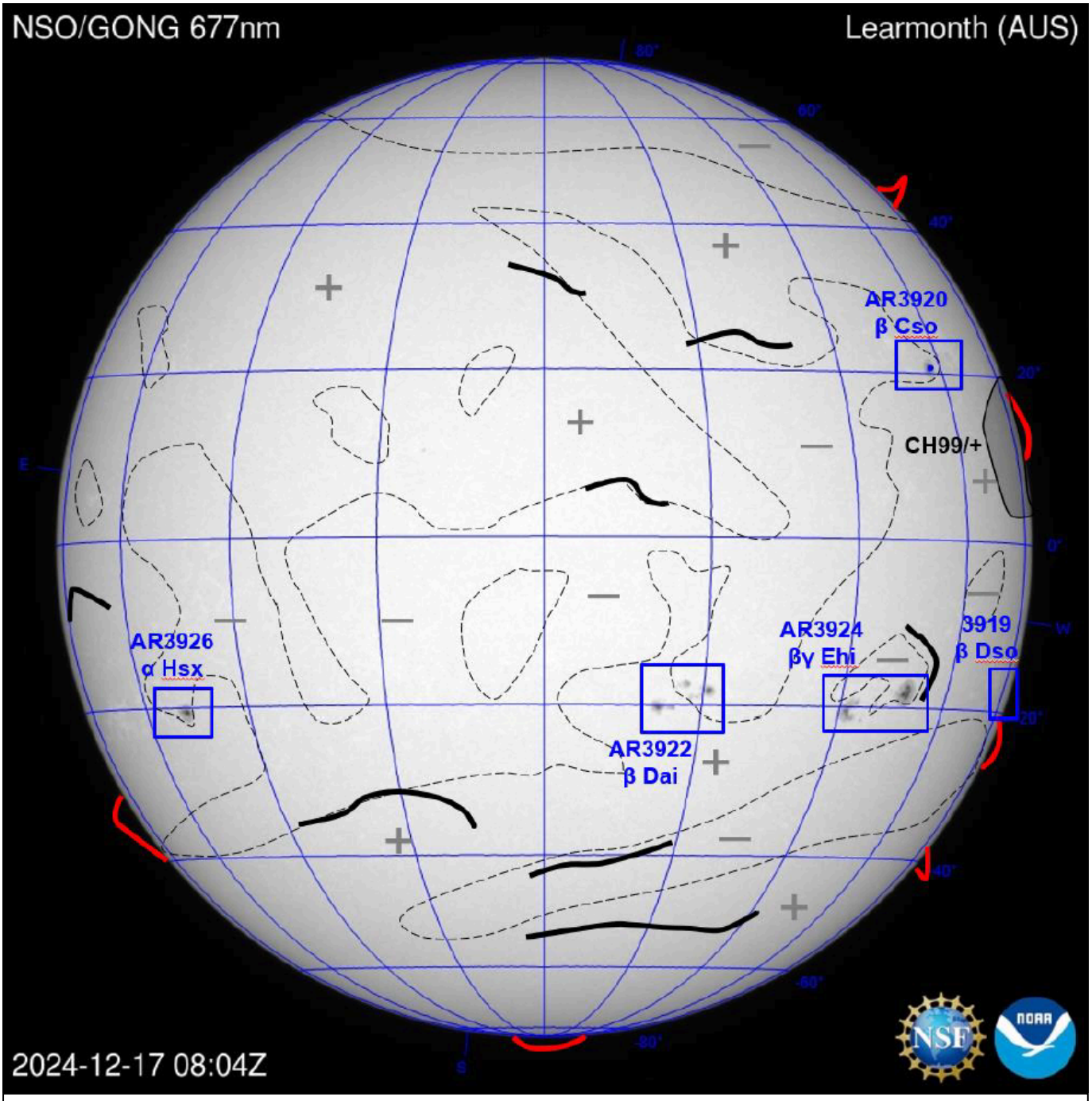
Figure 1: Solar Analysis valid 17/0800Z



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms

The unexpected CME which arrived at Earth early on the 17th is thought to be associated with a large and complex filament eruption that occurred early on the 15th. Most of the ejecta from the filament appeared to go south and west out of the solar system and away from Earth, but there was evidence of a very faint and fast shock front emanating from the Sun shortly afterwards, as seen only on STEREO A coronagraph. There have been no further significant CMEs observed in the Earth-Sun line. A few other filaments have also erupted early on the 17th, but are not thought to be Earth-directed. No coronal holes are expected to play in the forecast period, so once the current CME has subsided, it is likely we will see a return to Quiet to Unsettled (Kp1-3) conditions, this most likely from Day 2 onwards (18th Dec).

Geomagnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	70	40	10	10
Strong	G3	No	20	5	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R⊙ (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed (km/s)	Estimated Arrival Time (UTC)	Comments
2024-12-15 10:43	Partial	Filament	SW	481	18/1900 UTC	A part of this CME has likely arrived already at Earth (timing 17/0437UTC), travelling much faster than initially observed.

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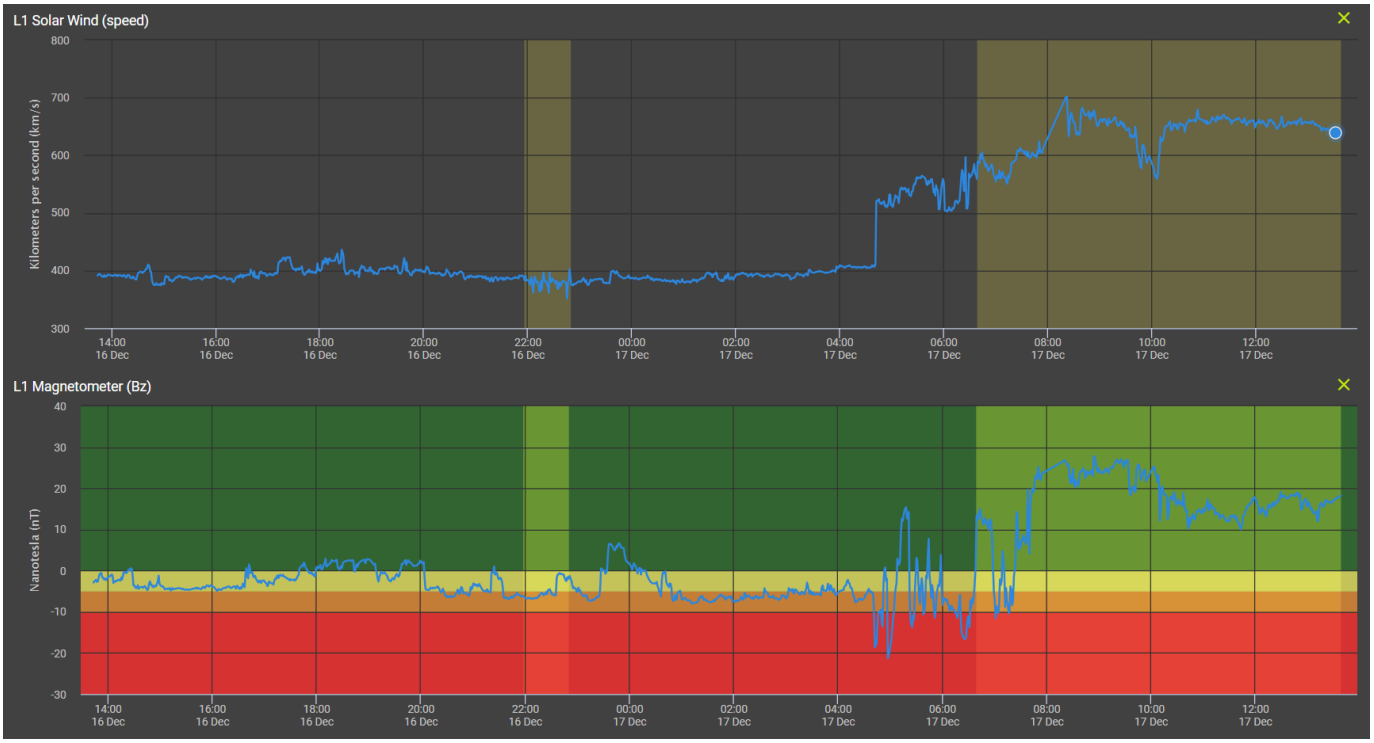
Figure 2: Solar wind speed (top) and Bz component (bottom) from DSCOVR/ACE(highlighted) showing sharp rise in activity from 0437UTC on the 17th as the CME arrived. Strongly positive magnetic cloud during the morning.



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Radio Blackouts - X-Ray Flares

Solar activity has been at Low levels for the last 24 hours with 5 active regions only giving isolated C-class flares. AR3924 in the southwest remains the most complex region and consists of a large, symmetrical leading spot and a smaller, but irregularly shaped trailing spot. Several smaller intermediate spots persist, though only evolving slowly. AR3922 also in the southwest remains the most developmental group on the disc. It continues to show signs of growth with emergence of spots in all parts of the group. Despite this the region remains largely stable and inactive. The remaining sunspot groups on the disc are smaller and more magnetically simple.

There continues to be the likelihood for further regions to rotate onto the disc from over the east limb between Days 1-3 (17-19 Dec) corresponding to Ex-AR3902, Ex-AR3905 and Ex-AR3906. The latter two produced M-class flares when they were last on the facing-disc and recent far-sided CME activity and helio-seismic soundings suggest that at least one of these regions remains active.

Low to Moderate Solar Activity is forecast with a chance of M-class flares increasing to become more likely from Day 2 (18 Dec) onwards.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	No	30	50	60	60
Very Active	R3-R5 (X Class)	No	1	5	5	5

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Solar Radiation Storms (High Energy Protons)

GOES18 proton flux is at background levels. There is a continuing slight chance of reaching S1/Minor Storm levels or greater, in response to any notable solar flares, currently most likely from AR3924. This region will likely rotate over the western horizon on Day 4 (19 Dec), but proton storm probabilities are maintained for at least 24-hours after it leaves the visible disc.

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	15	15	15	15
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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High Energy Electrons (≥ 2MeV)

High energy electron flux observed by GOES16 has been at background levels following the influence of the HSS from CH99+. The electron flux may see moderate peaks in the diurnal cycle during in the coming days but are likely to remain mainly at background throughout. The associated 24-hour fluence is well below the Active (1e8 integrated flux) threshold and expected to remain below this throughout the forecast period. MOSWOC REFM output is considered to be providing good guidance.

GEO Electron Environment	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ 1×10^{8}	No	1	1	1	1
Very Active	≥ 2 MeV ≥ 1×10^{9}	No	1	1	1	1

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